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著者	Yamato Yuya, Shen Zhenjiang, Mardin Rifai
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Spatial Planning and Management based on Stages for Evacuation Shelters using Elementary Schools in Japan

Yuya Yamato^{1,2} and Zhenjiang Shen^{1*} and Rifai Mardin^{1,3}

1 School of Environmental Design, Kanazawa University

2 National Institute of Technology, Fukui College

3 Engineering Faculty, Tadulako University

* Corresponding Author, Email: shenzhe@se.kanazawa-u.ac.jp

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Abstract: Elementary schools are usually designated as evacuation shelters during a disaster. Based on this regulation, it is essential to plan the evacuation space in evacuation shelters, including for disaster management control centres, crisis centres, and so on. Since the primary function of the elementary school is for educational activities, it is also essential to consider the education space during the use as an evacuation shelter. When making an evacuation shelter management plan, it is necessary to examine the relationship between the evacuation space and the education space. Based on this relationship, it is possible to show the utilized area. In addition, it is essential to consider the process of operating an evacuation shelter from the occurrence of a disaster based on the stage of evacuation. This study aims to show a method of spatial planning based on floor area distribution and management depending on the stage of evacuation. This investigation confirms the priority level of activity spaces for both the evacuation and education needs. The research confirms the priority level of facilities (activity space needed) for planning the evacuation space and the education space. In addition, the research conducts classification of type by prioritizing activity space between the evacuation space and the education space. The result identifies four types of spatial planning and management methods based on stage of evacuation.

1. INTRODUCTION

In Japan, elementary schools are usually designated as evacuation shelters for disasters. Japanese regulations require spatial planning for evacuation shelters. There are three things that should be considered in the use of elementary schools as evacuation shelters. Firstly, there must be living space for evacuees in evacuation shelters (hereinafter, living space), where the evacuees can sleep and eat. Secondly, there must be space (hereinafter, evacuation space) which is the necessary space for the evacuee for other daily activities. Evacuation spaces are used for evacuation shelter management and serve as disaster management control centres, and include every available space for evacuees excluding the living space. Third, since the primary function of the elementary school is to facilitate educational activities, it is also important to consider the sustainability of education activity space

(hereinafter, education space) during the use of the school as an evacuation shelter.

In real evacuation situations, there are some cases where it is not possible to accommodate all evacuees due to limited space. In those cases, it is necessary to restrict allocation of evacuation spaces and the education spaces for low priority use. Misallocation of evacuation spaces and education spaces has been reported in past disasters. In the Kumamoto earthquake, the allocation of evacuation space and education space was reported as an issue ([Board of education Kumamoto prefecture 2018](#)). In the Great East Japan Earthquake, it was reported that there was an issue in resuming school because classrooms were used as living space ([Ministry of Education, Culture, Sports, Science and Technology, 2012](#)). In addition, the management of evacuation shelters depends on which function they are being utilized for at a given time. Therefore, it is important to consider the process of operating evacuation shelters as it relates to different stages of disaster response.

In some cases, evacuees cannot be adequately accommodated, even in plans that restrict the allocation of the evacuation space and the education space to high priority. In those cases, reduction of individual living space and distribution of evacuees to other facilities are options. However, [Ohkouchi et al. \(2013\)](#) point out one problem when individual living space is insufficient: in order to avoid crowded situations in evacuation shelters, some evacuees live in their cars. It is also important for evacuation management plans to account for the distribution of other facilities, however, [Furukawa, Hirata, and Ishikawa \(2015\)](#) argue that allocating evacuees to shelters other than their designated shelters is dangerousⁱ.

In recent years, the national and prefectural governments have published guidelines of evacuation shelter management for municipalities. The guidelines describe planning considerations for ideal evacuation shelter locations, prohibited locations, and standard living areas. However, there is no guideline for setting priority levels of evacuation spaces. In addition, the continuation of school activities requires planning the education space during the initial planning stage. Regarding the education spaces, it is necessary to examine the frequency of use of classrooms, measured by hours of class.

Considering the large size of the evacuation and education spaces, their distribution should be carefully planned; therefore, it is important to examine the floor area distribution ratio of the three main functions in the evacuation centre, the evacuation, education, and living space.

There are many studies on evacuation space, education space, and evacuee accommodation. [Motoyoshi et al. \(2005\)](#) conducted a simulation to discuss evacuation and education spaces. Regarding the evacuation space, [Kobayashi, Ichiko, and Nakabayashi \(2010\)](#) describe the utilization method of the evacuation space over time. [Takita and Kumagai \(2002\)](#) conclude that evacuation shelter management is focused on evacuation space. [Sakata et al. \(1997\)](#) explain that it is essential to plan corresponding to the condition of the evacuation shelter. [Mikami et al. \(2009\)](#) set the priority level of the evacuation space by assessing each evacuation space independently. [Haga, Kim, and Mitsuhashi \(2008\)](#) clarify the actual condition and tendencies of some evacuation shelter facilities to improve evacuation shelter management plans. Regarding the education space, [Nakano et al. \(2013\)](#) describe the necessity of early resumption of education after a disaster. [Mutch \(2015\)](#) describes the necessity of education for the mental recovery of students after a disaster. In addition, regarding the accommodation of evacuees in shelters, [Furukawa, Hirata, and Ishikawa \(2015\)](#) conducted an assessment of evacuation shelter

capacity. [Thanh, Shen, and Kenichi \(2017\)](#) suggest a method of identifying evacuees who cannot be accommodated in a particular evacuation shelter.

In previous studies, researchers have mainly focused solely on the evacuation space or the education space, and have not discussed the simultaneous use for evacuation and education more deeply; in addition, there is a missing discussion of the occupancy by evacuees of evacuation shelters. This study aims to provide a method for spatial planning focusing on floor area distribution and management based on changing stages of disaster response. This investigation confirms the priority levels for activity spaces according to evacuation and educational needs. Furthermore, the study identifies classification types by prioritizing the activity space between the evacuation use and the educational use and presents a plan of the facilities, detailing priority levels and management based on four types within each stage. Then, it shows improvement through an analysis of appropriate spatial planning in Miki district, Kaga city, Ishikawa prefecture. This study analyses an evacuation shelter management plan made by residents and school administrators, and shows examples of methods for making revisions; in addition, the method of planning is presented according to priority level. Previous studies do not include planning for both evacuation and education spaces in evacuation shelter management plans. This paper therefore contributes a planning method to aid residents and municipalities to make effective evacuation shelter management plans. In addition, it demonstrates how to dually plan for effective evacuation shelter management and the post-disaster continuation of education. Currently, there have been few cases in which residents and school administrators have jointly built a consensus during the planning process. Miki district has been selected as an advanced case in the Block Conference on measuring evacuation action and suitable living conditions in the evacuation shelter ([Cabinet Office, 2013](#)). Therefore, for the purpose of planning, it set up a council in the city and promoted a policy that accounts for the resumption of school education. As this study focuses on the relation between the evacuation space and the education space, Miki district is used as the case study.

2. METHOD

There are several steps which are taken in this research. The first step is creating a situation for the planning ([Section 3](#)). The second step ([Section 4](#)) consists of three phases. The [first phase](#) confirms the evacuation space to be planned from the guidelines; this paper takes the additional step of confirming the priority level of the evacuation space by setting the priority score of each factor/activity space. The [second phase](#) checks the frequency of classroom usage from the hours of class for each grade and confirms the importance of the education space from the priority score setting. In the [third phase](#), after measuring the importance of the evacuation space and the education space, classification types are identified using factors that prioritise the evacuation and education space. The result displays an appropriate floor area distribution; in the last step in this research ([Section 5](#)), an analysis is carried out in Miki district, Kaga city, Ishikawa prefecture.

3. PLANNING ASSUMPTIONS

Since the number of students, classrooms, and evacuees varies depending on the conditions of the elementary school, the data used to set the models of this study are shown in [Table 1](#). The time of shelter life is assumed for an extended period, which is one month or more in the case of a large-scale disaster such as an earthquake or tsunami. Therefore, this research assumes that the evacuees and the students simultaneously use the school facility. To classify the stage of disaster response from the actual situation of evacuation shelter management during a disaster, this research refers to the actual situation of the Great Hanshin earthquake ([Kashihara, Morita, & Ueno, 1998](#)) and the national guideline ([Cabinet Office, 2016](#)). The four stages are given below, referring to both earthquake disasters.

Table 1. Situation of shelter management in this study

Assumption situation	Stage or number
Stage of shelter life	Divided into four stages.
Damaged infrastructure and places requiring repair after disaster	Not determined
Number of evacuees	300 people
Number of children	315 people
Number of normal classrooms	10 classrooms
Number of normal classrooms for education	6 classrooms (minimum)

- Initial response stage (disaster occurs over a three day period): this is the period when the number of evacuees is highest and the evacuees are most disorganised.
- Ensuring sheltered-life stage (from three days until one week after the initial event): the number of evacuees begins to reduce, the operation of the evacuation shelter is taken into consideration as a whole school, and the evacuation space is expanded.
- Emergency response stage (between one week and one month after the event): evacuees begin to show their self-reliance, teachers and staff can concentrate on schoolwork, and it is time for school education to start. The school setting is rearranged, the evacuation space is reduced, and the education space is expanded. After restarting the education process, in the initial period, the student activity mainly takes place in the normal classrooms, but as time passes, classes in the special classrooms are begun.
- Recovery stage (after one month): in this period, the evacuation area is further reduced. Classes in special classrooms are conducted, as are classes following the regular curriculum.

Damaged infrastructure and places requiring repair are elements to be discovered after a disaster and are therefore not considered when making an evacuation shelter plan. The number of evacuees are assumed to be 300 people ([Ministry of Education, Culture, Sports, Science and Technology, 2016](#)), which were the average number of evacuees in the Kumamoto earthquake case. The number of students per school is 315 people, taken from the national average for 2012 ([Ministry of Education, Culture, Sports, Science and Technology, 2014](#)). There are an assumed ten normal classrooms with about 32 students per class. These numbers can be applied to many districts since they are average numbers for elementary schools in Japan. There are at least six standard classrooms for education. In considering the actual conditionsⁱⁱ of the Kumamoto earthquake, there were a large number of evacuees and more than 90% of children were present for education in the evacuation shelters.

Therefore, it is assumed that about 90% of the students attend classes, and each of the six classes has about 47 students.

4. EVACUATION AND EDUCATION, LIVING SPACE PLANNING, AND MANAGEMENT BASED ON STAGES

This section describes the installation of the evacuation space and the education space based on classroom use frequency, and confirms the priority level of each factor/activity space and the floor area. Following this, classification types are identified by prioritizing activity space between the evacuation space and the education space, and methods are presented for planning spaces by floor area distribution and management based on stages divided into four types/categories.

4.1 The priority level of the evacuation space and its installation

The guidelines for prefectures are summarized as those that are published on each prefecture's webpage and those that are obtained from a questionnaire survey of people in charge of prefectures. It is assumed for prefectures that have either not determined or published their guidelines that they refer to the guidelines of the national government. Based on these considerations, 23 prefectures in which evacuation space is described as per the guidelines are extracted. The survey is established based on the guidelines in January 2017. To be planned for evacuation space, facilities which are described in the guidelines of the national government and those which are not, but which comply with 50% or more of the prefectural guidelines, are extracted. These are organised in [Table 2](#). Additionally, it is necessary to consider that the guidelines are not limited to elementary schools. Non-target facilities include napping places, water supply stations for staff, restrooms for people who panic, smoking places, morgue areas, and dining rooms. Since the living space is necessarily planned, it is not shown in [Table 2](#).

Table 2. The condition of guidelines of evacuation space and place to be planned (N=23)

Evacuation space to be planned	Number of described places in guidelines (Ratio)	Places described in guidelines	Needs a room (*2)
Headquarters	23 (100.0)	Near entrance. A place where electricity is available.	✓
Bulletin board	23 (100.0)	Near the entrance so it can be seen by many evacuees.	
Reception	23 (100.0)	Near entrance.	
Nurse's office	22 (95.7)	Clean and quiet place such as infirmary.	✓
Storage place of food and goods	23 (100.0)	Cool place, away from direct sunlight.	
Distribution place of food and goods	21 (91.3)	Wide space indoor. In case of outdoor, tent arrangement.	
Telephone	19 (82.6)	A place where voices cannot be heard in the living room.	
Counselling room	19 (82.6)	A place away from the living space.	✓
Isolation room	8 (34.8)	A place away from the walking route.	✓

Evacuation space to be planned	Number of described places in guidelines (Ratio)	Places described in guidelines	Needs a room (*2)
Dressing room	23 (100.0)	Separate room that cannot be seen into, separated by gender.	✓
Nursing room	23 (100.0)	Room where hot water is around the corner. Room with Japanese style room or carpet.	✓
Community room	19 (82.6)	In initial response stage, it may be a space where chairs are set.	
Cooking room	19 (82.6)	If there is no indoor cooking space, outdoor is used.	
Study and playroom	19 (82.6)	A place away from the living space.	
Welfare evacuation room (*1)	15 (65.2)	A place near toilet or nurse's office.	
Toilet	23 (100.0)	Japanese style room or room with carpet.	
Garbage place	23 (100.0)	A place that is far from the living room, which cannot cause problems due to smell.	
Unloading place	17 (73.9)	A place where the garbage truck can easily collect garbage.	
Smoking place (*1)	19 (82.6)	A place where trucks can enter easily.	
Public bath	23 (100.0)	A place away from the living space.	
Laundry	22 (95.7)	A place where wastewater can be treated.	
Parking (*1)	15 (65.2)	A place where wastewater can be treated.	
Place for pets	22 (95.2)	This place is considered to be used by women.	
		Playground. Transport truck for goods, garbage truck, and official vehicle park.	
		A place where barking and smells do not bother evacuees.	

(*1) Facilities are not described as facilities to be planned in the guideline of the national government.

(*2) Summarized in the guidelines of the prefecture. It is a reference only and not required by law.

Among contents described in the guidelines, the ratio of isolation rooms is low, however, they are necessary to install for the prevention of infectious disease during winter time. There is also a guideline regarding the use of combined dressing rooms and nursing rooms using partitions. Regarding the welfare evacuation room, the establishment of welfare evacuation centres in the guidelines of the national government is described in detail. However, there is no description for people who need support in evacuation centres. According to the guidelines of the national government, prohibited locations are only described in the outline; there is no detailed description of how to cope with such problems. Therefore, this research organised contents of prohibited locations using the guidelines for each prefecture (Table 3). Firstly, there is "facility with equipment and chemicals", which include science rooms and machinery equipment rooms. Secondly, there is "classrooms to consider from the viewpoint of facility managers", those are the principal's office and teachers' rooms.

Table 3. Prohibited locations (N=23)

Prohibited locations	Number of described places in guidelines of prefecture (Ratio)
Machine room and chemical room	9 (39.1)
Classroom to consider from the viewpoint of facility manager	12 (52.2)

The living area of individuals is not described in the guideline of the national government, therefore, the most frequently described living area from the guidelines of prefectures has been organised as shown in Table 4. The

living area of individuals should be widened based on the stage of evacuation that is described in the guidelines of the prefecture. It is stated that there is no municipality assistance for three days immediately following the event of a large-scale disaster; the evacuation shelter must be managed by the evacuees, therefore, it is necessary to predetermine the living area of individuals when making an evacuation shelter plan so as to not to cause confusion. 2m²/person is considered appropriate and should be planned for, which is the area that an individual can use for sleep during the initial response period.

Table 4. Living area of individuals (N=6)

Area per person	Assumption of situation
1m ² /person	The area of condition sitting during the initial response
2 m ² /person	It is possible to sleep during emergency response
3 m ² /person	Shelter life for long-stage, the space includes baggage area

To measure the priority level of the evacuation space, this research assigns factor/activity space points (priority score) which are derived and calculated from their equivalent in the relevant guidelines. The guideline points are calculated from the guidelines of the national government and prefectures. The process of calculating the priority score is by converting the points scale to equal a total of 100 points. The conversion itself is not applied to those facilities with weak relationships between elements of the evacuation space, including the bulletin board, reception, telephone and outdoor, and the education space and the space occupied by evacuees. The priority scores of the evacuation spaces are shown in Table 5. For each facility, including the classroom to be used, this research refers to the guidelines ([Chiba Prefecture, 2016](#); [Kouchi Prefecture, 2014](#); [Mie Prefecture, 2013](#)). In addition, for the floor area of each classroom, the research refers to *Kenchikugakutaikei 32* ([Kawasumi et al., 1975](#)). Since the storage place of food and goods and the distribution place of food and goods are difficult to define as usable spaces, this research refers to an area that is described in the Handbook of Engineering for Disaster Prevention in a Park ([Association of Engineering for Disaster Prevention in a Green Park, 2000](#)).

Table 5. Priority score of evacuation space and floor area required for each activity space

Evacuation space	Guideline points	Priority score	Priority level	Classroom to use	Floor area (m ²)
Headquarters	24	10	High	Audio-visual room	59
Storage place of food and goods	24	10		-	39
Dressing room	24	10		Normal classroom	66
Nursing room	24	10		Normal classroom	66
Nurse's office	23	9		Infirmery/First-aid room	45
Distribution place of food and goods	22	9		-	39
Community room	20	8		Library	84
Cooking room	20	8		School kitchen	127
Counselling room	20	8		Counselling room	10
Study and playroom	20	8		Normal classroom	66
Welfare evacuation room	15	6		Janitor's room	23
Isolation room	9	4		Normal classroom	66
Total	-	100	-	-	690

As for the validity of this method, prefectures that do not publish guidelines are presumed to refer to the guideline of the national government; therefore, making it possible to know the nationwide trend by creating a

priority score based on the guidelines of the national government and prefectures. Currently, it is difficult to manage evacuation shelters unless the priority score (hereinafter, important activity spaces of the evacuation space) is at least 9 or 10, hence additional facilities need to be installed.

As the evacuation space plan and their priority level have been established, in order to clarify the validity of the determined importance of each facility, real evacuation shelter situations are investigated ([Ministry of Education, Culture, Sports, Science and Technology, 2012](#)). In the report, when there is no facility having a high priority score, it is assumed to be unable to be managed as an evacuation shelter. Facilities with low priority scores, in many cases, were established depending on the time relative to a disaster event, or after an evacuation stage had passed. Therefore, it is considered that there is validity for a method of setting a priority score for evacuation spaces. Furthermore, the national guideline describes the period for which an evacuation space should be established. In the guideline, all those designated as important activity spaces should be established from the initial stage. Therefore, when there are no facilities having a high priority score, it is assumed they are unable to be managed as evacuation shelters.

4.2 Determining the education space and priority level based on classroom frequency of use

The frequency of use of the classrooms is based on the number of classes which are stated in [Table 1](#) of the Enforcement Regulations of the School Education Act (Section 51) and its class hours. This research calculates average class hours of each subject from the first to the sixth grade by totalling the classroom to be used for each subject. The education space is determined from the frequency of use of the classroom ([Table 6](#)). Additionally, classrooms for home economics, music and art are assumed to be held in a special classroom. Classrooms for the subjects of life studies, or for the period of integrated study and special activities, are not targeted because the classroom used differs depending on the content of the class. Classrooms that can conduct classes similar to a normal classroom, such as a learning room or special support school are treated as normal classrooms. At the time of class resumption, it is necessary to preferentially conduct classes for normal classroom subjects with a large number of classes, such as national languages and mathematics. However, it is necessary in some cases to conduct subjects with fewer burdens on the mental state of students.

Table 6. Education space from the standpoint of classroom frequency of use

Subject	Grade						Average	Classroom to use	Number of class hours
	1	2	3	4	5	6			
Japanese	306	315	245	245	175	175	243.5		
Social studies	-	-	70	90	100	105	60.8		
Arithmetic	136	175	175	175	175	175	168.5	Normal classroom	586.8
Moral education	34	35	35	35	35	35	34.8		
English	-	-	-	-	35	35	11.7		
Science	-	-	90	105	105	105	67.5		
Physical education	102	105	105	105	90	90	99.5	Outside	99.5
Art	68	70	60	60	50	50	59.7	Art room	59.7
Music	68	70	60	60	50	50	59.7	Music room	59.7

Subject	Grade						Average	Classroom to use	Number of class hours
	1	2	3	4	5	6			
Home economics	-	-	-	-	60	50	19.2	Home economics room	19.2
Total	714	770	840	875	875	875	824.9	-	824.9

The importance of each activity space in the education space is recognised by using the priority score. The setting of the priority score is the same as for the evacuation space, and it is conducted only in the classrooms that are affected by a transition between an education space and living space. Physical education is not targeted, and since the science room may be restricted, science subjects are resumed in normal classrooms. The priority score is a result of the average number of class hours in each classroom. This research sets the total possible points of each activity space to 100 points. The floor area ([Kawasumi et al., 1975](#)) for each classroom is shown in [Table 7](#). The minimum total area for normal classrooms is $66 \text{ m}^2 \times 6 \text{ classes} = 396 \text{ m}^2$, as set in [Section 3](#). Normal classrooms have restricted use when the priority score is 81 points (hereinafter, the important activity space of the education space). It is necessary to consider the important activity spaces of the education space when making an evacuation shelter plan. Moreover, the number of normal classrooms depends on the number of students, situation of the school, relationship with the evacuation space, and the number of the evacuees. Therefore, it is necessary that the number of classrooms as the education space is confirmed by the residents and school administrator from the beginning of the planning process.

Table 7. Priority score of the education space

Name of classroom	Number of class hours	Average	Priority score	Priority level	Floor area (m ²)
Normal classroom (6)	586.8	0.81	81	High	396
Art room	59.7	0.08	8	<div style="text-align: center;"> \updownarrow </div>	78
Music room	59.7	0.08	8		92
Home economics room	19.2	0.03	3		92
Total	725.4	1.00	100	-	658

4.3 Spatial planning and management type classification based on the stage

In this section, the activity space is classified as either evacuation space or education space based on priority and explains the planning of space by type based on floor area distribution and management depending on the stage of evacuation. The floor area ([Kawasumi et al., 1975](#)) of each facility is shown in [Table 8](#). This can be used as a reference standard for elementary school planning.

Table 8. Floor area of each facility

Name of facilities	Floor area m ² (%)	Name of facilities	Floor area m ² (%)
Normal classroom (10)	660 (38.9)	Janitor's room	23 (1.4)
Music room	92 (5.4)	Infirmary	45 (2.7)
Art room	78 (4.6)	School kitchen	127 (7.5)
Home economics room	92 (5.4)	Audio-visual room	59 (3.5)
Library	84 (5.0)	Counselling room	10 (0.6)

Name of facilities	Floor area m ² (%)	Name of facilities	Floor area m ² (%)
Gymnasium	425 (25.1)	Total	1,695 (100.0)

The spatial area henceforth is distributed between evacuation space, education space, and living space. Moreover, in the making of the evacuation shelter management plan, it is essential to exclude facilities from prohibited locations and other facilities which are difficult to use, as shown in [Table 3](#). Furthermore, by planning the evacuation space and the education space in activity spaces with high importance, it is easy to manage the evacuation shelters, and it is possible to create an environment that makes it easy for students to receive their education.

This research classifies activity spaces based on priority, namely the evacuation space, the education space and the living space. Four aspects are considered for each of the classification types. Detailed data of the floor area distributed for each type is shown in [Table 9](#). For each type, the evacuation space and the education space need to be established based on the priority score. However, for all types, it is necessary to set important activity spaces for evacuation and education. Areas utilized for evacuation space and education space comprise the total area of all classrooms. Since the floor area of the evacuation space and the education space are calculated based on each classroom, in cases where infrastructure is damaged, the same area is distributed between each activity space. The calculation of floor area is shown in [Table 10](#).

Table 9. Floor area distribution of the evacuation, education, and living spaces by type

Type	Evacuation space		Education space		Living space		Total m ² (%)
A	Priority score	100	Priority score	81	Capacity	301	-
	Floor area	693 (40.9)	Floor area	399 (23.5)	Floor area	603 (35.6)	1695 (100.0)
B	Priority score	58	Priority score	100	Capacity	320	-
	Floor area	355 (21.0)	Floor area	699 (41.2)	Floor area	641 (37.8)	1695 (100.0)
C	Priority score	58	Priority score	81	Capacity	492	-
	Floor area	314 (18.5)	Floor area	396 (23.4)	Floor area	985 (58.1)	1695 (100.0)
D	Priority score	90	Priority score	89	Capacity	303	-
	Floor area	607 (35.8)	Floor area	481 (28.4)	Floor area	607 (35.8)	1695 (100.0)

Table 10. Calculation of floor area for the evacuation, education, and living spaces

A-type	Calculation formula	Area (m ²)
Evacuation space	690(All items of evacuation space) +3(Damaged infrastructure)	693
Education space	66*6(Important activity space for education space) +3(Damaged infrastructure)	399
Living space	600(300*2m ² /person) +3(Damaged infrastructure)	603
B-type	Calculation formula	Area (m ²)
Evacuation space	59+39+66+66+45+39(Important activity space for evacuation space) +41(Damaged infrastructure)	355

Education space	658(All items of education space) +41(Damaged infrastructure)	699
Living space	600(300person*2m ² /person) +41(Damaged infrastructure)	641
C-type	Calculation formula	Area (m ²)
Evacuation space	59+39+66+66+45+39(Important activity space for evacuation space)	314
Education space	66*6(Important activity space for education space) 1695(Area of school)-314(Important activity space for evacuation space)-396(Important activity space for education space)	396
Living space		985
D-type	Calculation formula	Area (m ²)
Evacuation space	(59+39+66+66+45+39) Important activity space for evacuation space+(84+127+10+66) Item points 8+6(Damaged infrastructure)	607
Education space	66*6(Important activity space for education space) +78(Art room, Item points 8) +7(Damaged infrastructure)	481
Living space	600(300person*2m ² /person) +7(Damaged infrastructure)	607

- **Type A: In the case of prioritising evacuation space**
The number of evacuees begins to reduce in this type, when it is necessary to consider evacuation shelter management as well as to restart school education in normal classrooms at the same time. This type should be applied during stages of evacuation where sheltered life needs to be ensured. Although the activity space of the evacuation space is considered large, setting important activity spaces within the education space is necessary. It is crucial to accommodate evacuees, and when they cannot be accommodated, it is necessary to reduce the space used based on lowest priority evacuation spaces. As shown in [Table 9](#), the evacuation space plans for all activity spaces, the education space is only the important activity space, and the living space is the area for assumed evacuees only. The area utilized for the evacuation space is the largest space utilized.
- **Type B: In the case prioritising education space**
Type B is a stage when evacuee numbers have reduced, and the evacuation space begins to be aggregated. Therefore, considering the use of special classrooms, the situation should be progressed to the emergency response stage and the recovery stage when it is necessary to reassign a large area for education space. Although it is considered that the area of the education space may be large, the arrangement of important activity spaces for the evacuation space remain necessary. In addition, it is important to accommodate evacuees, and when they cannot be accommodated, it is necessary to restrict the education space where there is low activity. As shown in [Table 9](#), the education space plans for all activity spaces, while the evacuation space is the least important activity space, and the living space is the area assumed for evacuees only.
- **Type C: In the case of prioritising evacuees' accommodation**
Type C should be applied to the initial response stage when the evacuation shelter is relatively disorganised at the first stage of a disaster. It assumes acceptance of evacuees from other areas, and the area of the living space is increased as much as possible. In this case, it is necessary to establish important activity spaces for the evacuation as well as for education, and when these facilities cannot be set up, it is necessary to reduce the area utilized as living space. As shown in [Table 9](#), the space utilized as living space uses the largest area.
- **Type D: In the case of prioritizing both evacuation space and education space**

Type D should be applied to the emergency response stage and the recovery stage assuming that school education has been restarted. It is during this stage that evacuation and educational activities coexist. The priority scores of the evacuation space and education space are similar, and close to the highest possible priority score. For this type, it is necessary to secure an area to where evacuees can be accommodated. When evacuees cannot be accommodated, it is necessary to restrict the activity spaces of the evacuation space and the education space based on low priority scores. As shown in [Table 9](#), although the area of the education space is small, the utilized area ratio is low compared to other types.

Moreover, it may be assumed that important activity space for both evacuation and education cannot be planned and evacuees cannot be accommodated. In this particular case, it would be necessary to secure capacity for evacuees by redirecting them to other designated evacuation shelters in which capacity is sufficient, or by stockpiling equipment that can stay outdoors in temporary tents.

In this section, the research confirms the priority level of the evacuation space, the education space and the living space. Types were classified by prioritizing the relationship between activity space, the evacuation space and the education space, and showed a method for spatial planning of the floor area, including distribution and management based on stage of evacuation. In addition, as the floor area of the classroom differs between each elementary school, and the classroom where the setting of each activity space is different, it is necessary to consider the floor area distribution of each activity space in each elementary school.

5. ANALYSIS FROM SPATIAL PLANNING IN MIKI DISTRICT

This section describes improvements by analysing an evacuation shelter management plan from the perspective of appropriate spatial planning. Kaga city, Ishikawa prefecture, which is the case study of this research, is located in the south of Ishikawa prefecture, and Miki district is located in the south of Kaga city ([Figure 1](#)). A past disaster in the Miki district was the Fukui earthquakeⁱⁱⁱ. During this event there were impacts such as one fatality, 25 injured people, 82 destroyed houses, and 130 half-collapsed houses. The earthquake was assumed to have a seismic intensity of 6 to 7 ([Kaga city, 2007](#)).

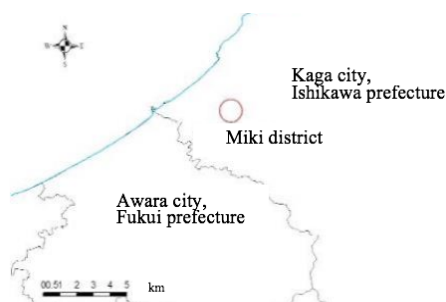


Figure 1. Location of case study

5.1 Planning in Miki district

The policy of planning was created by a committee^{iv} which held ten meetings. Furthermore, since the resumption of educational activities was important to the committee, the residents conducted meetings with school administrators and the role of the city office was to support them. The process of the planning was conducted across three meetings held with the residents, school administrators, and the municipality.

A meeting was also held in co-operation with a city/disaster prevention society^v with expert knowledge and with the residents who operate the evacuation shelter. The education space was determined by the school administrator, such as its function and room necessities for educational activities, lines for students' movement, and structure of the building.

5.2 Analysis of spatial planning

This section outlines the evacuation shelter management plan for the case study, analyses it, and outlines areas where spatial planning can be improved. The results show the area selected for the evacuation space, education space and living space in [Table 11](#), [Figure 2](#) and [Figure 3](#).

The evacuation space has a priority score of 92 points and the education space scored 81 points, while the area is predominantly utilized for evacuation space. Points of the evacuation space and education space were extracted based on the points shown in [Table 5](#) and [Table 7](#) in [Section 4](#).

The evacuation space is planned for uses other than important activities, while the education space is solely for important activities. Therefore, the type classification for the case study is type-A (refer to [Section 4](#)). The evacuation space was the priority, and the floor area of the living space was small. In this case, it was necessary to restrict the evacuation space and to secure the living space. Installation of the welfare evacuation room is necessary because it is a district where the importance of the welfare evacuation room is low but the population is older. One of the activity spaces that can be restricted in the evacuation space is the counselling room. The number of evacuees assumed in [Table 1](#) is an average value to be applied to many elementary schools, which is different from the number of evacuees in Miki district of the case study.

It is adequate to set the counselling room after the number of evacuees have decreased. In addition, community rooms do not have to be independent rooms, and they may be substituted by setting chairs and desks in a common space until evacuees have settled in. Moreover, it is possible to secure the floor area for evacuees by reorganizing facilities. For example, in the case of Miki district, although the nursing room and dressing room were separately planned for women, as the living space is insufficient, it is necessary to organize them into one room based on the guidelines. In this case, it is necessary to know the number of adult female evacuees and to discuss with the department concerned with women's affairs in the district. Based on one of the evacuation space considerations mentioned above, it is possible to secure the living space. As an example, as shown in [Table 11](#), when the community room is planned in a hallway, it is feasible to accommodate between 369 to 400 evacuees.

This section described the improvement of the plan that was analysed in the case study based on area distribution of types A-D. Since the evacuation shelter management plan varies from district to district, in this study case, the research extracted one type only as a sample. As with this method, it is

possible to make or to improve the planning of another elementary school type in other districts.

Table 11. Floor area of evacuation, education, and living space

	Evacuation space	Education space	Living space (*)	Total m ² (%)
Original	Priority score	92	81	-
	Capacity	-	-	369
	Floor area	547 (37.0)	191 (12.9)	741(50.1)
Continuous improvement	Priority score	84	79	-
	Capacity	-	-	400
	Floor area	485 (32.8)	191(12.9)	803(54.3)

(*) Number of evacuees is 383 people in Miki primary school ([Kaga city, 2014](#))

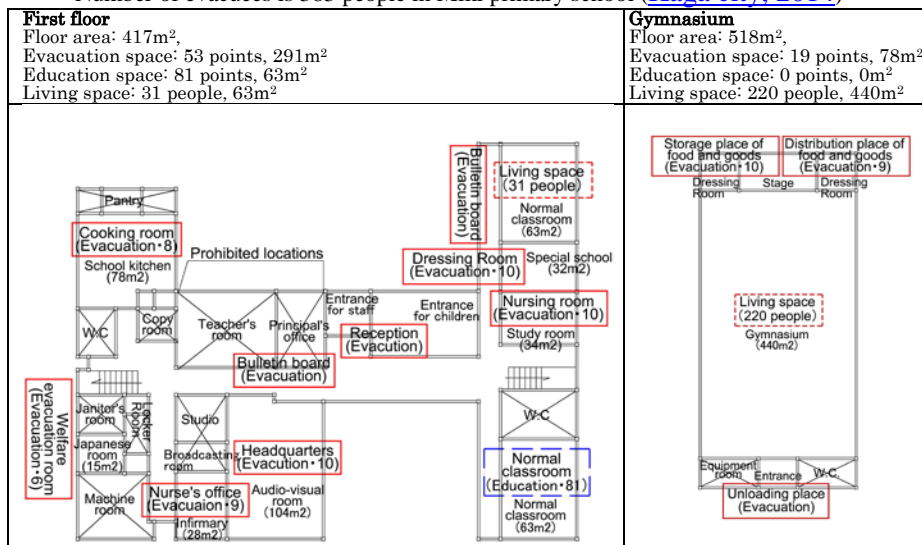


Figure 2. Floor area of evacuation, education, living space (First floor, Gymnasium)

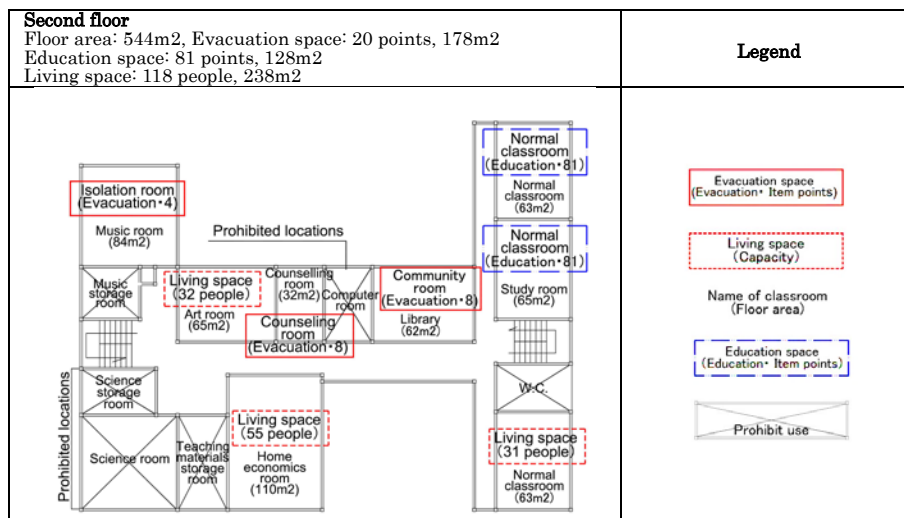


Figure 3. Floor area of evacuation, education, and living space (Second floor)

6. CONCLUSION

This research determined evacuation space and priority level based on the guidelines of national and municipal governments. In addition, this research determined the necessary education space based on frequency of use of the

classroom and confirmed their priority levels. Moreover, the research classified the spaces based on type, with priority given to evacuation space (type-A), priority given to education space (type-B), priority given to evacuees' accommodation (type-C), or priority given to both evacuation space and education space (type-D), and showed the planning of space based on floor area distribution, and management based on four stages of evacuation. The study proposed improvements to the plan, as per the analysis of Miki district in the case study which demonstrates area distribution based on priority types A-D. Future research should describe the method of assessment for spatial planning of the evacuation space and the education space at designated shelters such as junior high schools and high schools, other than elementary schools, and consider spatial planning at all evacuation centres. Thereby, it will be possible to know the condition of evacuation shelters in the city.

NOTES

- i. It has been pointed out that there is a lack of designed evacuation facilities in the neighbourhood, especially that there is a possibility of problems regarding information from the administration and relief goods.
- ii. The researchers investigated the timing of resumption of elementary schools, and the number of students attending classes for resumption in municipalities with more than 2,001 evacuees. The earliest resumption of education at an elementary school was April 26th, 2016.
The Kumamoto earthquake occurred on April 14th, 2016.
- iii. Miki district recorded magnitude 7.1 on June 28, 1948.
- iv. The committee consists of the disaster prevention organization chairman in Kaga city, disaster prevention organization vice chairman in Kaga city, disaster prevention leader organization chairman in Kaga city, chairman of the female committee in Kaga city, elementary school director in Kaga city, junior high school director in Kaga city, doctor in Kaga city, and employee in Kaga city.
- v. People who are certified by the Japan Bousaisi Organization, who are expected to improve disaster reduction and disaster prevention at various places in society, and to have sufficient awareness, knowledge, and skills.

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